CAST IRON WATER PIPE FOR PRESSURES HIGHER THAN ALLOWED BY CURRENT SPECIFICATIONS[1]

By C. E. Inman[2]

Criticism of the weights of, and stresses in, cast iron pipe manufactured under the specifications of this Association doubtless leads to the request for a brief experience paper. It should not seem in the least boastful to say, in complying with this request, that the "experience" covers many years and work as foreman, supervisor of construction or as superintendent in a number of different and widely separated cities. The weights of pipe used in those cities were fixed by engineers, or in some cases by the author. Speaking generally, those weights fall below the weights in the Association's specifications as the following table will indicate.

Weight in pounds per foot, including bells, for various diameters pipe

INCHES	POUNDS
6	28.92
8	40.50
10	56.17
12	73.75
14	90.67
16	106.75
18	126.67
20	153.43
24	210.33

Lake Shore Foundry standard weights for pipe

INCHES	POUNDS
6	33
8	42
10	60
12	75

The author began his water works experience in the year 1885 and worked under excellent contracting firms, who employed able engineers.

It was the custom to depend on the engineers' requirements for the proper weight. The foundries were willing to furnish pipe under

[1] Presented before the Philadelphia Convention, May 17, 1922.

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the engineers' specifications with a standard test, often under strict inspection.

A good quality of material was not always received. This caused some replacements when the time came to test the systems, but the cost for new pipe and labor was billed against the foundry furnishing the pipe, paid without hesitation upon assurance that the pipe had been carefully handled, properly laid and showed foundry defects.

Comparison of the above weights with the present A.W.W.A. specifications shows that some are even lighter than Class "A." In each town or city where this weight pipe was used, the pressure was always run up to 150 pounds per square inch on the completion of the work and in one city the pressure was increased every day at noon to 120 pounds, which was continued for 25 years. In this particular city, as well as in a number of others, there has occurred, as far as the author has been informed, only one failure on account of light weight pipe and that is mentioned below.

An employee of an eastern city who has been connected with the city water department for over 30 years writes thus: "In regard to pipes bursting, I do not think there has ever been any, unless there were flaws in the castings. The 'A' pipe seems to stand the pressure as well as the 'B.'"

The author has filed letters from those in charge of water departments in most of the cities herein referred to and after 27 to 37 years of service there are no criticisms regarding the original service mains or of those laid more recently.

Allow me to quote again from letters received, first from a water works in Massachusetts built in 1885.

The writer has used some Class E, New England pipe but will use Class A American, in the smaller sizes, at least, in the future. We have had no trouble whatever with cracks due to pressure, and believe that Class A pipe is good for working pressures up to at least 100 pounds.

Second, of a city in Ohio.

We might just as well buy Class A, for we did use some here, and, to my knowledge, we have not had any burst pipe due to its weight, as all our fractures were straight around the pipe as though caused by settlement. I think we will try Class A on our next extension. We carry 60 pounds domestic pressure and 100 pounds for fire.

Third, of a city in Wisconsin.

A pressure of 65 pounds is maintained at the plant. This has been raised to 100 pounds for a few fires. We have had no failures of the old pipe due to excessive water pressure or water hammer, within the past ten years.

In the city of Warren, Ohio, where the author is now with the Water Department, the plant was built in 1887 by Samuel R. Bullock & Co. It comprised 12 miles of mains and since then 46 miles have been added.

The original pipe compares with Class "B," while many miles of the pipe as added from time to time were even lighter than Class "A," yet all have stood the test of years of service with a domestic pressure of 60 pounds and fire pressure of 100 to 120 pounds, with sometimes more when called for. In all these years only one pipe burst from pressure and then the gauge went over 150 pounds.

In 1909 the Warren, Ohio, works were appraised and showed over 2000 tons of pipe. If we suppose the next heavier class of pipe had been laid for the sizes and mileage at the date of the appraisal, it would have added approximately 500 tons. This quantity at present quotations, say $40.00 per ton, would increase the cost $20,000. For the period from 1909 to 1922, or 13 years, the interest compounded yearly together with the principal, would amount to $42,600. Can this Association indorse such expenditure?

During the past season we had occasion to make several Smith taps in the city mains and found the thicknesses as follows:

12 inch pipe	34 years old	0.65 of an inch thick, corresponding to about half way between Class "B" and "C"
8 inch pipe	5 years old	0.51, equals Class "B"
6 inch pipe	With age from 34 years down to 4 years	With thickness of 0.55, equals Class "D" 0.50, equals Class "C" 0.47, equals Class "B" 0.42 and 0.37, equals lighter than Class "A"

A foundry test of 300 pounds to the square inch with vigorous hammer blows was required for the added pipe. All have been in service under identical working pressures as mentioned above.

The following quotation published by the late Geo. A. Ellis, at one time city engineer of Springfield, Mass., and later a member of this Association, seems still worthy of the attention of our membership. It was published about the year 1887.

This has been the subject of discussion and experiment among engineers for a long time, and the general verdict seems to be that we should apply the same fair, common-sense principles to this question as to any other, and not use a 6-inch pipe weighing 40 pounds to the foot, because somebody else does, when one weighing 28 pounds will answer the same purpose with equal safety. After a careful study of all the conditions under which cast iron pipes are used, it would appear that a factor of safety of 5 is ample to cover all the reasonable faults of manufacture, danger of handling and shock while under use.

The opinion of Mr. Ellis was based upon his extensive experience. Other engineers and superintendents have reached similar conclusions.

If Classes "A," "B," "C" and "D," under 20 inches in diameter, are tested at the foundry under 300 pounds pressure, all poured from the same quality of metal, why recommend class "A" for 43 pounds, Class "B" for 86 pounds, Class "C" for 130 pounds, and Class "D" for 173 pounds pressure per square inch.

Disturbance of the ground, as in sewer construction, causes unexpected stresses in water mains, but even then a tough close grained pipe free from dross and blow holes, with tensile strength according to the specifications, will be found more satisfactory than a heavier pipe without these qualities.

A friendly discussion on the above subject may mean the elimination of one or two classes of pipe as now stipulated, with a higher pressure allowable for the remaining classes. The same satisfactory results may be obtainable with a saving of money.

DISCUSSION

MR. J. N. CHESTER:[3] I wish to add to the inference of Mr. Inman's paper that higher pressures may be used than the specifications now in vogue and to cite you a well defined instance. There are here tonight members of that organization formerly known as the American Waterworks and Guaranty Company, now the American Waterworks and Electric Company. I became associated with that organization in 1899, and they were then laying about 100 miles of pipe a year, and probably 85 per cent of that was 6-inch. The general manager, Mr. Purdy, who is still the Vice President, and a man who has few

[3] Consulting Engineer, Pittsburgh, Pa.

peers in the waterworks business, had what I thought a queer streak in him in that he contended that 30-pound 6-inch pipe was heavy enough for any place. Their specifications then, and I believe they continue still, called for all their 6-inch pipe to be 30-pound pipe. Now I went on laying that because I was compelled to, but I soon became converted because we had no more trouble with 30-pound 6-inch pipe. Pressures varied all the way in our distribution systems from 25, in some of the flat western cities, up to over 125 pounds in some of the mountain cities of western Pennsylvania. The climax came, however, when we took over the South Pittsburgh Water Company where the hills varied 300 and 400 feet in height and we pumped water twice, the first time against 165 and the second time against 185 pounds. I anticipated that Mr. Purdy would weaken on the 6-inch 30-pound specification, but he stood pat and we laid miles and miles of it in South Pittsburgh, and not the majority but a great deal of it was subjected to 250 and 300 pounds working pressure. It stood the test and is standing it today. They have no more breaks in the South Pittsburgh Water Company, with the pressure varying from 35 to 300 pounds on the 30-pound 6-inch pipe, than they would have if they had laid class D. I am sometimes constrained, from the experience I had in that connection, to believe that those who formulated the present requirements, although I believe they used their best judgment and did not intend anything ill or evil to us, loaded the waterworks plants of this country with a great deal more cast iron than the conditions of service warranted placing below the ground. I am still willing to use 30-pound 6-inch pipe anywhere under ordinary conditions and under some extraordinary conditions. Just how far this will carry out in sizes larger than 6-inch I have never experimented, because when we left 6-inch pipe we used ordinary formula. We bought very little beyond class B and never used class D unless it was for discharge lines.

MR. W. F. WILCOX:[4] I can confirm what Mr. Chester says. For many years in the South we laid only 30 pound 6-inch and 56-pound 10-inch pipe. I know of at least 25-pound pipe where the pressure was as high as 150 pounds. Some of that pipe has been in use since 1888 and is still good, and the per cent of fracture is very small. But there is another point about the question that has something to

[4] Consulting Engineer, Birmingham, Ala.

do, I think, with our weights under the old specifications. We rarely went over 19,000 pounds tensile strength. Now we have gone on up into the high tensile strengths and have laid class B pipe that had 36,000 pounds tensile strength, and it has blown up like glass rods.

MR. C. E. INMAN:[2] I had a talk handed me today with a few pages by Mr. Alexander Potter, who is called back to New York, in reference to some pipe tested in Texas, that was laid in 1877 and tested in 1912. A section of the city was taken comprising approximately two miles of pipe and the pressure upon it was used to see how good it was. The 4-, 6-, 8- and 10-inch were all class A pipe; the 12-inch in this section was class C. They ran the pressure up to 160 pounds, by pumping into the system with a fire engine, and did not burst anything.

MR. LEONARD METCALF:[5] Just one word to call the attention of the members, who may be interested in looking it up, to the fact that in the discussions of the New England Waterworks Association standard specification, there will be found reference to these pipe weights and to their very general use in New England for a considerable period of years. They correspond to class A of the New England Waterworks Association weights, which were somewhat lighter than the American Waterworks Association weights. Those pipe sizes were not only 6-inch, but 8, 10 and 12. I know of such lines, miles of them, that have been used under pressures of 125 pounds for decades now.

[5] Consulting Engineer, Boston, Mass.